

**ADVANCED GCE
MATHEMATICS**

Mechanics 3

MONDAY 2 JUNE 2008

4730/01

Morning
Time: 1 hour 30 minutes

Additional materials: Answer Booklet (8 pages)
List of Formulae (MF1)

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the spaces provided on the answer booklet.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Answer **all** the questions.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question or is clearly appropriate.
- The acceleration due to gravity is denoted by $g \text{ m s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.
- You are permitted to use a graphical calculator in this paper.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [] at the end of each question or part question.
- The total number of marks for this paper is 72.
- **You are reminded of the need for clear presentation in your answers.**

This document consists of 4 printed pages.

- 1 A particle P of mass m kg is attached to one end of a light elastic string of natural length 1.8 m and modulus of elasticity $1.35mg$ N. The other end of the string is attached to a fixed point O on a smooth horizontal surface. P is held at rest at a point on the surface 3 m from O . The particle is then released. Find

(i) the initial acceleration of P , [3]

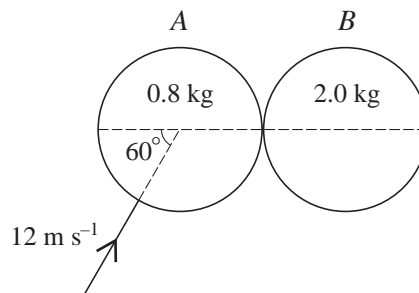
(ii) the speed of P at the instant the string becomes slack. [3]

- 2 A particle P of mass 0.2 kg is moving with speed 8 m s^{-1} when it hits a horizontal smooth surface. The direction of motion of P immediately before impact makes an angle of 27° with the surface. Given that the coefficient of restitution between the particle and the surface is 0.6, find

(i) the vertical component of the velocity of P immediately after impact, [3]

(ii) the magnitude of the impulse exerted on P . [3]

3



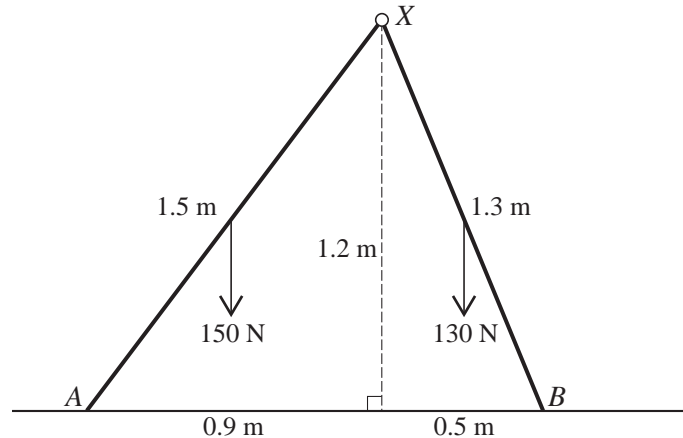
Two uniform smooth spheres A and B , of equal radius, have masses 0.8 kg and 2.0 kg respectively. The spheres are on a horizontal surface. A is moving with speed 12 m s^{-1} at 60° to the line of centres when it collides with B , which is stationary (see diagram). The coefficient of restitution between the spheres is 0.75. Find the speed and direction of motion of A immediately after the collision. [10]

- 4 A particle P of mass m kg is held at rest at a point O on a fixed plane inclined at an angle $\sin^{-1}(\frac{4}{7})$ to the horizontal. P is released and moves down the plane. The total resistance acting on P is $0.2mv$ N, where $v \text{ m s}^{-1}$ is the velocity of P at time t s after leaving O .

(i) Show that $5\frac{dv}{dt} = 28 - v$ and hence find an expression for v in terms of t . [8]

(ii) Find the acceleration of P when $t = 10$. [2]

5



Two uniform rods XA and XB are freely jointed at X . The lengths of the rods are 1.5 m and 1.3 m respectively, and their weights are 150 N and 130 N respectively. The rods are in equilibrium in a vertical plane with A and B in contact with a rough horizontal surface. A and B are at distances horizontally from X of 0.9 m and 0.5 m respectively, and X is 1.2 m above the surface (see diagram).

(i) The normal components of the contact forces acting on the rods at A and B are R_A N and R_B N respectively. Show that $R_A = 125$ and find R_B . [4]

(ii) Find the frictional components of the contact forces acting on the rods at A and B . [4]

(iii) Find the horizontal and vertical components of the force exerted on XA at X , stating their directions. [3]

6 A particle P of mass 0.1 kg moves in a straight line on a smooth horizontal surface. A force of $(0.36 - 0.144x)$ N acts on P in the direction from O to P , where x m is the displacement of P from a point O on the surface at time t s.

(i) By using the substitution $x = y + 2.5$, or otherwise, show that P moves with simple harmonic motion of period 5.24 s, correct to 3 significant figures. [5]

The maximum value of x during the motion is 3.

(ii) Write down the amplitude of P 's motion and find the two possible values of x for which P 's speed is 0.48 m s^{-1} . [4]

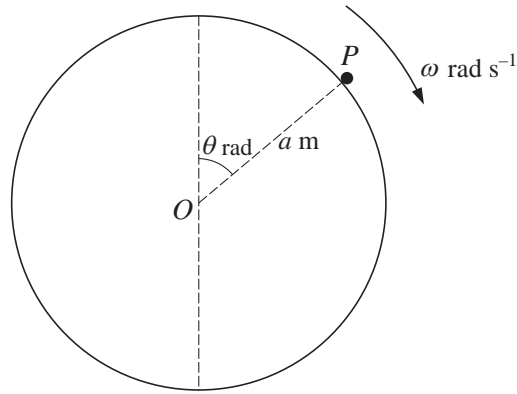
(iii) On each of the first two occasions when P has speed 0.48 m s^{-1} , P is moving towards O . Find the time interval between

(a) these first two occasions,

(b) the second and third occasions when P has speed 0.48 m s^{-1} .

[5]

[Question 7 is printed overleaf.]



A particle P of mass m kg is slightly disturbed from rest at the highest point on the surface of a smooth fixed sphere of radius a m and centre O . The particle starts to move downwards on the surface. While P remains on the surface OP makes an angle of θ radians with the upward vertical and has angular speed ω rad s^{-1} (see diagram). The sphere exerts a force of magnitude R N on P .

(i) Show that $a\omega^2 = 2g(1 - \cos \theta)$. [3]

(ii) Find an expression for R in terms of m , g and θ . [4]

At the instant that P loses contact with the surface of the sphere, find

(iii) the transverse component of the acceleration of P , [4]

(iv) the rate of change of R with respect to time t , in terms of m , g and a . [4]

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